Thermal Management Characteristics for a Fuel Cell Hybrid Vehicle Under Realistic Driving Demands

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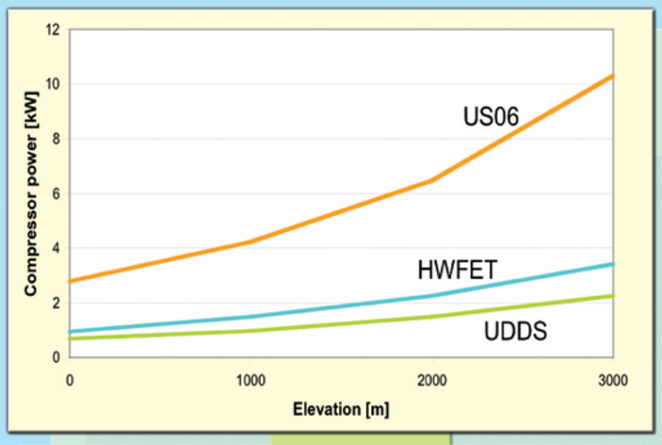
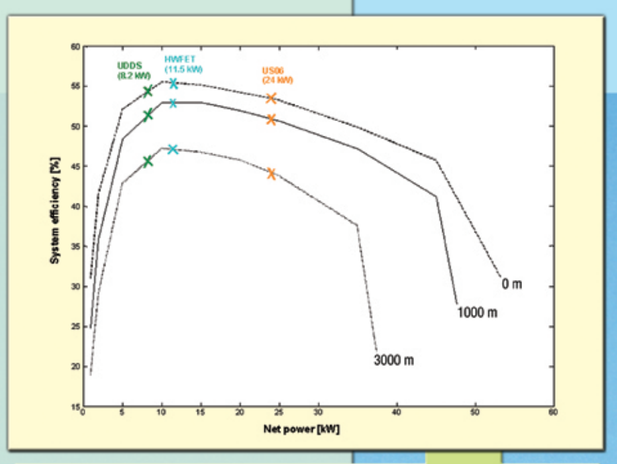
ADVISOR Advanced Vehicle Simulator

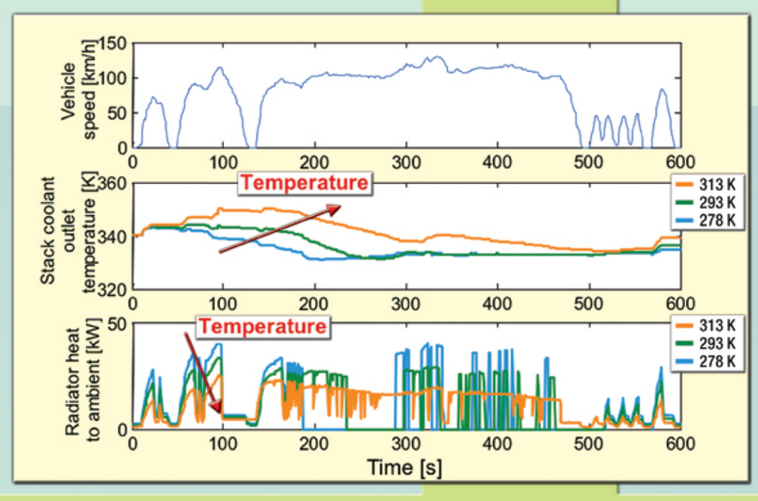


Increase in air compressor parasitic load with increasing elevation (T = 293 K, RH = 50%, hot start 340 K)

Because ambient pressure decreases with increasing elevation and operating pressure is assumed to increase linearly with power demand, the compressor must work harder with increasing elevation to provide the desired pressure ratio. This contributes to an overall decrease in fuel cell system efficiency.



Decrease in fuel cell system efficiency with increasing elevation (X's denote average net power required by given drive cycle)

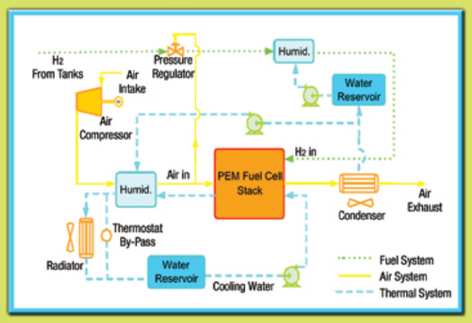


Effects of ambient temperature on the fuel cell system during the US06 drive cycle (elevation = 0 m, hot start 340 K)

Fuel cell stack operating temperature is more difficult to control at higher ambient temperatures because heat rejection from the radiator is limited.

This simulation study explored the effects of ambient temperature and pressure (as a function of elevation) on fuel cell hybrid vehicle performance. A compact fuel cell hybrid vehicle was defined in ADVISOR™ and simulated over several drive cycles at different ambient temperatures and pressures.

Schematic of the fuel cell system model used in the study



Characteristics of simulated fuel cell hybrid vehicle used in the study

Vehicle mass	1364 kg (with powertrain)
FC system	50 kWe (pressurized)
Motor/controller	70 kW AC induction motor/inverter
Energy storage system	6 Ah Li-ion battery pack

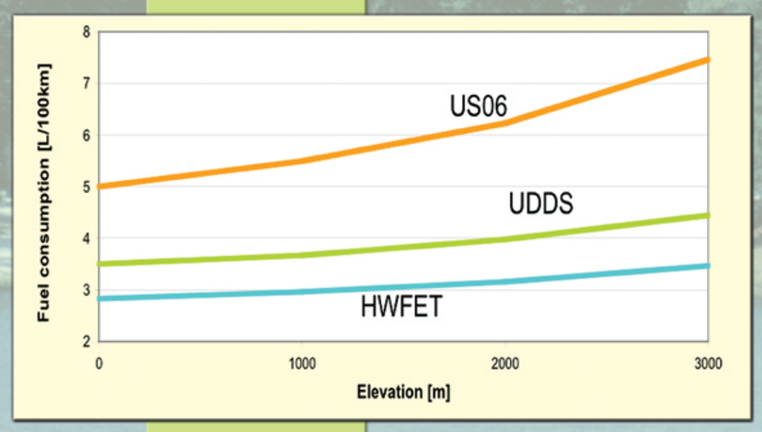
Drive cycles used in the study

UDDS	Typical urban driving
HWFET	High-speed, moderate-acceleration-rate driving
US06	High-speed, high-acceleration-rate driving
NREL2Vail	Logged route from Golden to Vail, Colorado

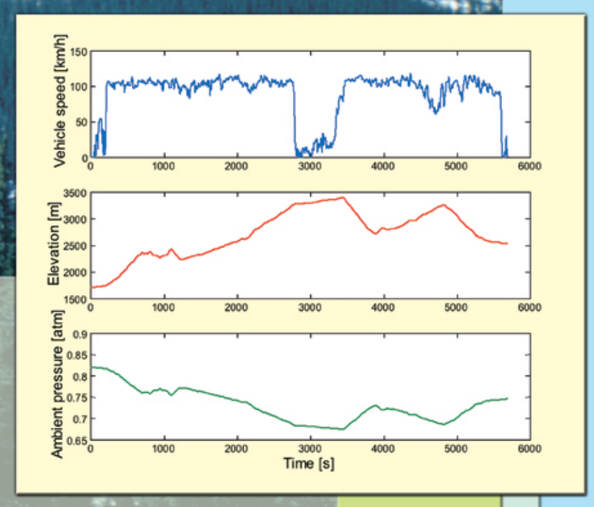
Conclusions

- **Fuel cell hybrid vehicle fuel consumption increases with increasing elevation; the effect of elevation on fuel consumption is greatest over the highest-power (US06) drive cycle.**
- **Fuel cell stack operating temperature is more difficult to control at higher ambient temperatures because heat rejection from the radiator is limited.**

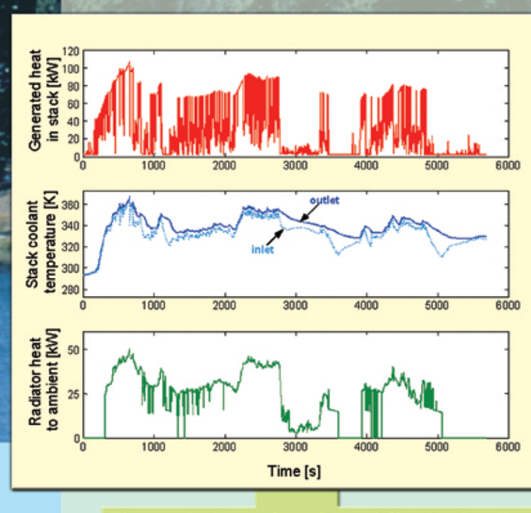
Fuel consumption increases approximately 20%-50% as elevation increases from 0-3000 m, with the greatest fuel consumption increase during the high-power US06 cycle. Increased air compressor parasitic load and reduced system efficiency at higher elevations contribute to increased fuel consumption.



Increase in fuel consumption with increasing elevation (T = 293 K, RH = 50%, hot start 340 K)



Driving profile for the logged route between Golden and Vail, Colorado (NREL2Vail cycle)



Thermal characteristics of the fuel cell system during the NREL2Vail cycle

The radiator is initially bypassed to raise the fuel cell stack temperature and system efficiency quickly. Once the system reaches normal operating temperature, the radiator fan, bypass valve, and vehicle speed keep the system at 333-348 K.